More colors more bias!

Sowmya Kamath, Joshua Meyers, Patricia Burchat
Stanford University, KIPAC

What bias?

We study the impact of spatially varying spectral energy distributions, SEDs (so-called **color gradients, CG**), on shear estimators due to the wavelength dependence of seeing for a ground-based telescope such as the **LSST**, and due to diffraction for a space-based mission such as **Euclid**[1].

Why the bias?

- Bias from CG is present only when the PSF is chromatic; i.e., its shape and/or size is wavelength dependent.
- Bias arises when a weight function is used in the shape measurement.
  - To suppress noise, shape measurements employ a radial weighting that is matched to the brightness profile of the galaxy. Hence the profile in the center is "weighted" more than the wings.
  - However the PSF correction will use the effective observed SED - i.e., the average of the entire unweighted galaxy image.

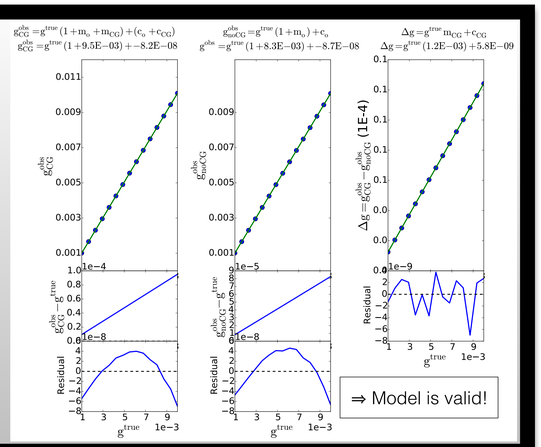
Model for quantifying CG bias

- Observed shear of galaxy with CG (g^{obs}_{CG}) is related to true shape (g^{true}) by multiplicative and additive biases, m and c.
- Bias values (m, c) are split into two terms, one resulting from CG effects (m_{CG} , c_{CG}) and the other from all other effects (m_o, c_o)

$$g^{obs}_{CG} = (1 + m)g^{true} + c$$
$$= (1 + m_o + m_{CG})g^{true} + (c_o + c_{CG})$$

$$g^{obs}_{noCG} = (1 + m_o)g^{true} + c_o$$

$$\Rightarrow \Delta g = g^{obs}_{CG} - g^{obs}_{noCG} = m_{CG}\, g^{true} + c_{CG}$$

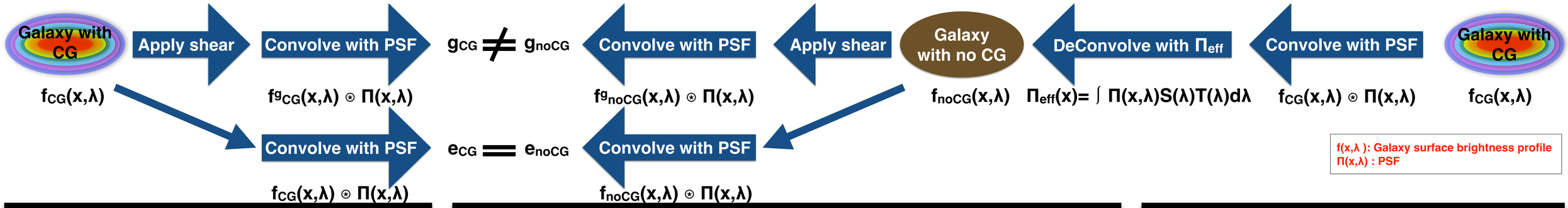


Conclusions

- Bias from CG is higher for Euclid due to broader filter.
- CG bias for LSST is lower than the requirement of m ~ 0.003, but close.
- The bias is a function of redshift and depends on how different the bulge and disk SEDs are.
- The bias has a strong dependence on the size of the weight function.
- In the absence of weight function, the bias from CG is zero.

Assumptions made in the study

- All simulations were free of noise to avoid noise bias washing out the bias due to CG.
- We assumed that the effective PSF is known given the composite SED of the galaxy.



f(x,λ): Galaxy surface brightness profile
Π(x,λ) : PSF

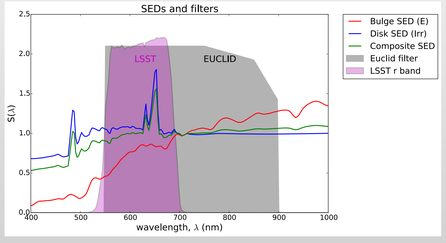
Measure the bias

- Take the simplest case: **co-elliptical co-centric bulge + disk galaxy with different SEDs.**
- Chromatic PSF $\Pi(x, \lambda)$ is Gaussian profile with wavelength dependent size;

$$\sigma_{PSF} = \sigma_o(\lambda/\lambda_o)^{\alpha}$$

α = 1.0 for Euclid (diffraction); α = -0.2 for LSST (atmospheric seeing)

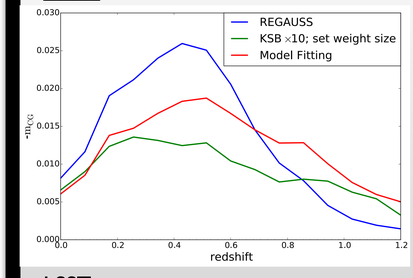
- SED used in PSF estimation is flux weighted average SED of galaxy.

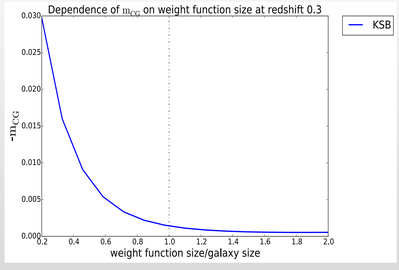


- To eliminate other measurement bias and measure **bias from CG only**, compare results of shape estimation of galaxy with CG to that of equivalent **galaxy with no CG**[2].
- Galaxy shape estimation methods used:
  - Moment based: **re-Gaussianization (REGAUSS)** using GalSim HSM package.
  - **Model fitting** galaxy to bulge + disk galaxy with composite SED
  - To observe effect of weight function size on bias, also use **KSB** method from HSM. Weight function size manually set, as opposed to REGAUSS, where weight function is obtained by adaptive moments method.

So… what is the bias?

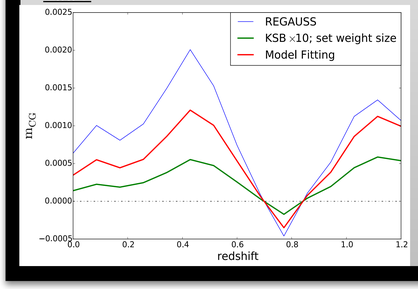
- Euclid

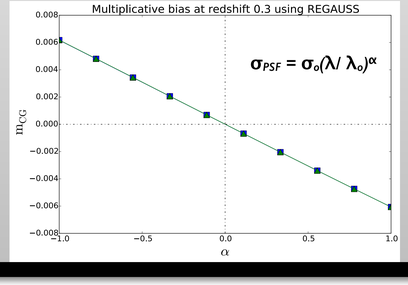




Parameters:
bulge HLR = 0.17 arcsec
disk HLR = 1.2
bulge n_S = 1.5 arcsec
disk n_S = 1.0
bulge frac = 0.25
σ_o = 0.102 arcsec
λ_o= 800 nm
α = 1

- LSST





Parameters:
bulge HLR = 0.17 arcsec
disk HLR = 1.2
bulge n_S = 1.5 arcsec
disk n_S = 1.0
bulge frac = 0.25
σ_o = 0.297 arcsec
λ_o= 550 nm
α = -0.2

Future Work

- This study is for a simple case of separable bulge and disk profiles with different SEDs.However, real galaxies are more complicated than this.
- The next step will be to apply the study to chromatic galaxies with a non-parametric form (GalSim ChromaticRealGalaxies, Joshua Meyers).
- This study was limited to only the PSF size being wavelength dependent. In reality the shape of the PSF may depend on the wavelength as well.This would likely increase the measured bias.
- The shape estimation methods to be used in LSST have not yet been finalized. It will be important to apply this study to the final methods to better predict the bias for LSST.

References

[1]Voigt et al. 2012, MNRAS, 421,1385
[2]Semboloni et al. 2013, MNRAS, 432, 2385
[3]Mandelbaum et al. 2005, MNRAS,361,1287